Development of a Dedicated Ethanol Ultra–Low Emissions Vehicle (ULEV)

Subcontractor

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Objective

To develop a dedicated ethanol (EtOH) or EtOH-gasoline blend-fueled vehicle that meets California's ultra-low emissions vehicle (ULEV) standards. The vehicle must be competitive in cost and performance with a gasoline-fueled vehicle. The fuel cost need not be competitive.

Approach

We are seeking to combine improvements in the engine and control systems with advanced aftertreatment devices. Three improvements in engine design were planned and have been accomplished, as follows:

Ford Taurus ethanol vehicle

1. The compression ratio has been increased from 9.3 to 11.0 to take advantage of EtOH's high octane number (>100 research).

2. Air–assist injectors developed at Southwest Research Institute have been installed in place of the standard pintle injectors to improve the atomization of the fuel and reduce fuel transport delays.

3. An engine controller developed at Southwest Research Institute has been used to improve the control of fuel:air ratio and spark timing.

Three types of advanced aftertreatment devices are being investigated:

1. An electrically heated catalyst (EHC) plus a reformulated main catalyst.

2. A hydrocarbon (HC) trap upstream of an EHC plus main catalyst.

3. A combined HC trap and light-off catalyst followed by a main catalyst.

Accomplishments

Using the engine modified as described above, very clean (engine-out) starts have been demonstrated in the Federal Test Procedure (FTP) temperature range (20°–30°C), with no or very few misfires throughout the starting process. (Results of a misfire-free cold start are shown in the figure.) This is accomplished by providing a fuel enrichment and ignition timing schedule on an individual cylinder event basis that varies with the initial engine coolant temperature.

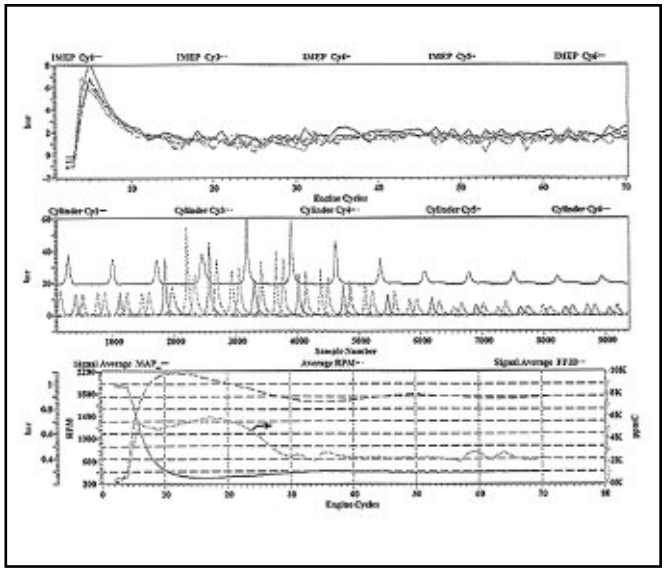
Even at lower temperatures, very strong engine startups have been demonstrated with minimal misfires. Work is continuing to extend the cold start calibration schedules over a broader temperature range, including temperatures as low as -29°C.

Work is currently being conducted to develop model-based control for transient fueling compensation, which is especially challenging with EtOH fuels because of their relatively low volatility. Fuel hang-up in the intake system is more significant than for gasoline, and requires more accurate estimates of extra fuel required for accelerations and reduced fueling during decelerations.

Tests of advanced aftertreatment systems are being conducted with a standard Ford Taurus flexible fuel vehicle (FFV) without the engine modifications described above. Following the tests of the advanced aftertreatment devices, the best aftertreatment device shall be installed on the vehicle with the modified engine. Tests with an electrically heated catalyst followed by a main catalyst have demonstrated nitric oxide (NO) and carbon monoxide (CO) levels lower than ULEV standards (for a vehicle/catalyst with about 4000 miles of use) by about a factor of 2. The HC emissions were still about 50% above ULEV standards. However, with the combination of advanced aftertreatment devices with the engine modified for clean startups, lower HC levels are expected. Testing of other advanced aftertreatment devices is currently under way.

Future Direction

Work is continuing to extend the starting calibration for very clean starts to a wider range of starting temperatures. Work on transient compensation to maintain tight control of the fuel:air ratio is under way. Tests with all three types of advanced aftertreatment devices have been completed and are being evaluated.

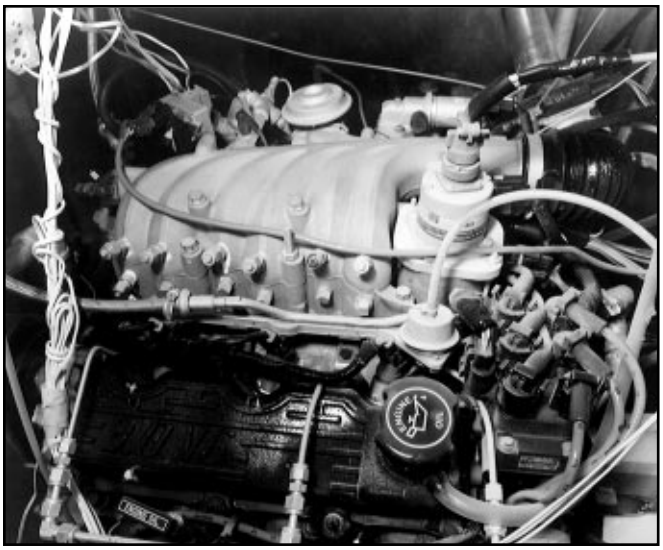


Publications

Dodge, L. 1994. "Development of a Dedicated Ethanol Ultra–Low Emissions Vehicle (ULEV)." Presented at the Contractors Coordination Meeting, Detroit, MI. October.

Dodge, L. et al. 1995. “Development of a Dedicated Ethanol Ultra Low Emission Vehicle—System Design Report”. Southwest Research Institute. NREL/TP-425-6722. February.

Dodge, L. et al. 1995. “Development of a Dedicated Ethanol ULEV—Phase II Report”. SwRI. NREL/TP-425-8195. September.



Ford Taurus FFV engine modified by SwRI for dedicated ethanol use